REMARKS

The application has been reviewed in light of the Office Action dated March 31, 2006. Claims 1-21 were pending. By this Amendment, new dependent claims 22 and 23 have been added, and claims 1, 13, 17 and 18 have been amended to clarify the claimed invention. Accordingly, claims 1-23 are now pending, with claims 1, 11, 15, 17 and 21 being in independent form.

Claim 14 was objected to under 37 C.F.R. 1.75 (c) as purportedly in improper form. Claims 17 and 18 were objected to as purportedly containing informalities.

By this Amendment, claims 13, 17 and 18 have been amended to clarify the claimed invention.

Withdrawal of the objections to the claims is requested.

Claims 1, 6, 9 and 10 were rejected under 35 U.S.C. § 102(e) as purportedly anticipated by U.S. Patent No. 6,335,620 to Weissenberger. Claims 2, 5, 11 and 13 were rejected under 35 U.S.C. § 103(a) as purportedly obvious over Weissenberger in view of U.S. Patent No. 5,770,943 to Zhou. Claims 3 and 4 were rejected under 35 U.S.C. § 103(a) as purportedly obvious over Weissenberger in view of U.S. Patent No. 5,352,979 to Conturo. Claims 7 and 8 were rejected under 35 U.S.C. § 103(a) as purportedly obvious over Weissenberger in view of Cohen, "Echo-planar imaging (EPI) and functional MRI".

Applicant has carefully considered the Examiner's comments and the cited art, and respectfully submits that independent claims 1 and 11 are patentable over the cited art, for at least the following reasons.

This application relates to improved techniques in an MRI apparatus for avoiding image quality deterioration which is caused by gradient magnetic field waveform distortion due to eddy

currents induced by application of a gradient magnetic field.

For example, independent claim 1 is directed to a magnetic resonance imaging apparatus comprising a phantom disposed in static magnetic field, eddy current measurement means and compensation current calculating means. The eddy current measurement means takes an image of the phantom by repeatedly executing an eddy current measurement sequence composed of an application of a test gradient magnetic field having an application time longer than a time constant of an eddy current as a measurement object and having a predetermined intensity in a predetermined axial direction and of a repetition in a plurality of times of a pulse sequence which is started in response to rising up and falling down of the test gradient magnetic field while changing phase encoding amount thereof. Further, the eddy current measurement means successively measures a plurality of image data containing magnetic field variation information due to eddy current induced by rising up and falling down of the test gradient magnetic field in a unit of the repetition time of the pulse sequence. By starting the pulse sequence in response to rising up as well as falling down of the test gradient magnetic field and measuring image data containing magnetic field variation information due to the eddy current induced by the rising as well as falling down of the test gradient magnetic field, more accurate measurement of magnetic field variation due to the induced eddy current can be obtained.

Independent claim 11 is directed to a magnetic resonance imaging apparatus comprising a magnetic field generating means, a signal transmission system which generates high frequency magnetic field for exciting nuclear spins in atoms constituting tissue of the subject, a signal receiving system which detects echo signals generated from the subject by mean of the high frequency gradient magnetic field, a signal processing system which reconstructs an image of the tissue of the subject by making use of the detected echo signals, and a control means which

controls the magnetic field generation means, signal transmission system, signal receiving system and the signal processing system according to a predetermined sequence. The control means is provided with as the pulse sequence a calibration pulse sequence including a pulse sequence group repeated in a plurality of times in a predetermined repetition time which includes a step of applying a test gradient magnetic field after causing to generate an echo signal through application of the high frequency excitation pulse and application of phase encoding gradient magnetic field and read out gradient magnetic field and executes the calibration sequence of two kinds in total which are formed by changing the polarity of the test gradient magnetic field with a plurality of phase encoding values. Thus, the test gradient magnetic field is applied during the pulse sequence group repeated in a plurality of times in a predetermined repetition time included in the calibration pulse sequence.

Weissenberger, as understood by Applicant, proposes an approach for measuring eddy currents that are caused by switched magnetic field gradients wherein a measuring gradient pulse that exhibits a prescribable pulse width is applied, and after the deactivation of the measuring gradient pulse, at least two imaging sequence blocks, one following the other at the spacing (t_1, t_2, t_n), are generated, with a complex data set being generated from the imaging signals, and with the phase information contained therein being proportional to the magnetic field strength.

Applicant does not find disclosure or suggestion in Weissenberger, however, of starting the pulse sequence in response to rising up as well as falling down of the test gradient magnetic field, and measuring image data containing magnetic field variation information due to the eddy current induced by the rising as well as falling down of the test gradient magnetic field, as provided by the claimed invention of claim 1 as amended.

Although Weissenberger recognizes that the magnetic field gradients have steep leading

and trailing edges and the steep edges induce eddy currents, Weissenberger fails to appreciate the desirability of starting the pulse sequence in response to rising up as well as falling down of the test gradient magnetic field, and measuring image data containing magnetic field variation information due to the eddy current induced by the rising as well as falling down of the test gradient magnetic field.

In addition, Applicant does not find disclosure or suggestion in Weissenberger that the test gradient magnetic field is applied during the pulse sequence group repeated in a plurality of times in a predetermined repetition time included in the calibration pulse sequence, as provided by the claimed invention of claim 11.

Zhou, as understood by Applicant, proposes an approach for determining spatially and temporally varying magnetic fields induced by eddy currents. Zhou proposes performing a calibration scan using a calibration pulse sequence which begins with a test gradient G_{test}, followed by a non-selective RF pulse with an optimal tip angle. The FID induced by the RF pulse is spatially encoded in 1, 2 or 3 dimensions (depending on the geometry of the phantom) using phase-encoding gradients. After spatial encoding, the FID signal continues to precess in the presence of a time-varying magnetic field produced by the eddy currents. Therefore, the temporal behavior of the eddy currents is also encoded in the FID signal. Due to the use of phase-encoding gradients, the time-varying magnetic field is caused by eddy currents arising from both G_{test} and the phase-encoding gradients. In order to remove the effects of the latter, as well as the effects of the static B_0 field inhomogeneities, the pulse sequence is repeated, but with an opposite test gradient polarity, $-G_{test}$.

Zhou was cited in the Office Action as purportedly proposing conducting the measurements twice at opposite polarities, reconstructing the data into phase images, and

subtracting the corresponding phase images in order to offset effects other than the eddy currents being studied.

However, Zhou, like Weissenberger, does not disclose or suggest (a) starting the pulse sequence in response to rising up as well as falling down of the test gradient magnetic field, and measuring image data containing magnetic field variation information due to the eddy current induced by the rising as well as falling down of the test gradient magnetic field, as provided by the claimed invention of claim 1 as amended, and (b) the test gradient magnetic field is applied during the pulse sequence group repeated in a plurality of times in a predetermined repetition time included in the calibration pulse sequence, as provided by the claimed invention of claim 11.

Conturo and Cohen were cited only against dependent claims in the application, and do not cure the above-mentioned deficiencies of Zhou and Weissenberger. Conturo, as understood by Applicant, proposes phase angle reconstruction imaging techniques for MRI. Conturo, column 11, lines 1-38, proposes an approach for correcting for eddy currents wherein several baseline acquisitions are obtained and averaged. Cohen, as understood by Applicant, proposes an approach for echo-planar imaging.

Applicant does not find disclosure or suggestion in the cited art, however, of (a) starting the pulse sequence in response to rising up as well as falling down of the test gradient magnetic field, and measuring image data containing magnetic field variation information due to the eddy current induced by the rising as well as falling down of the test gradient magnetic field, as provided by the claimed invention of claim 1 as amended, and (b) the test gradient magnetic field is applied during the pulse sequence group repeated in a plurality of times in a predetermined repetition time included in the calibration pulse sequence, as provided by the claimed invention of claim 11.

Accordingly, Applicant respectfully submits that independent claims 1 and 11, and the claims depending therefrom, are patentable over the cited art.

In addition, the cited art does not disclose or suggest claim 8 of the present application which provides that the test gradient magnetic field is contained in a form of respective pulse like gradient magnetic field in the pulse sequence repeatedly executed. Such a feature is also not disclosed or suggested in Cohen, as understood.

The Office Action indicates that claims 15-21 have been allowed. Applicant appreciates the Examiner's statement of reasons for allowance in the Office Action and submits that the allowed claims recite subject matter which further supports patentability for reasons in addition to those identified in the Examiner's statement of reasons for allowance in the Office Action.

In view of the amendments to the claims and remarks hereinabove, Applicant submits that the application is now in condition for allowance. Accordingly, Applicant earnestly solicits the allowance of the application.

If a petition for an extension of time is required to make this response timely, this paper should be considered to be such a petition. The Patent Office is hereby authorized to charge any fees that may be required in connection with this amendment and to credit any overpayment to our Deposit Account No. 03-3125.

If a telephone interview could advance the prosecution of this application, the Examiner is respectfully requested to call the undersigned attorney.

Respectfully submitted,

Paul Teng

Paul Teng, Reg. No. 40,837
Attorney for Applicant
Cooper & Dunham LLP
Tel.: (212) 278-0400